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ABSTRACT

Because of the increasing use of microelectronic componentry in automobiles, vocational educators must reexamine existing automotive mechanics curricula to ensure that they can continue to provide relevant job training. After examining recent trends in the impact of computers and electronics on automotive design and engineering, existing auto mechanics curricula in Hawaii, and the views of selected automotive technology professionals in the State, the Hawaii State Advisory Council on Vocational Education recommended that (1) curriculum content identification and validation surveys of automotive service industry employers be conducted to reflect recent technological innovations in the field; (2) individualized, self-study courses be developed to enable high school automotive technology (AMT) students to gain advanced diagnostic, repair, and servicing skills; (3) horizontal articulation among community college AMT programs be examined; (4) alternative curricula be developed to improve the delivery of AMT training; and (5) the requirement that graduates of two-year AMT programs work for at least one year before taking the written portion of the State's motor vehicle mechanic certification test be eliminated. (Appendixes to this report contain a discussion of the technological innovations in the Toyota FX-1, motor vehicle certification examination results, and a description of the organization of AMT curricula by proficiency level.) (MN)

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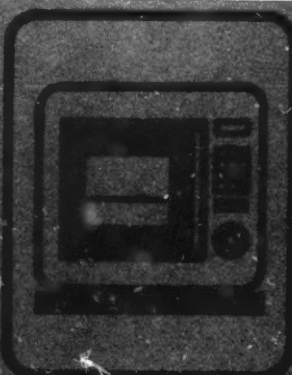
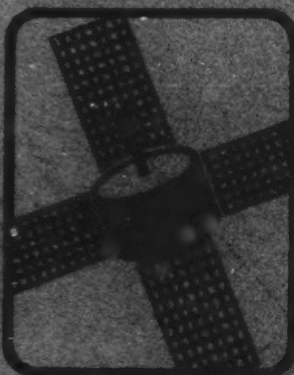
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PREFACE

Chapter 202, Hawaii Revised Statutes, assigns the State Commission on Manpower and Full Employment (CMFE) responsibility for identifying, describing and assessing the effects of technological change on Hawaii's economy and labor force. Because of the accelerating pace of technological change and innovation, the Commission decided to initiate a series of technological impact studies in 1982.

The first two studies in the series focused on (i) the impact of word processors and desk-top computers on the office industry in Hawaii; and (ii) Hawaii's electronics industry. This study, the third in the series, examines the impact of new technologies on the education, training, and supply of automobile mechanics in Hawaii.

The Commission, in its role as the State Advisory Council on Vocational Education (SACVE), is required under P.L. 94-482 to "identify the vocational education and employment and training needs of the State and assess the extent to which vocational education, employment training, vocational rehabilitation, special education and other programs...represent a consistent, integrated, and coordinated approach to meeting these needs." In response to this mandate, a summary of the present study was published previously in the 1983 Annual Report of the Hawaii State Advisory Council on Vocational Education.

The Commission wishes to thank the many automotive industry professionals who contributed to the preparation of the report. If there are any questions about the report or the Commission's technological impact study series, please call the Commission staff at 548-2630.

TABLE OF CONTENTS

	<u>Page</u>
Preface	1
Part I: Introduction	1
Part II: The Impact of Technology on Automotive Design and Engineering	3
Part III: Labor Supply and Demand	9
Part IV: Interviews	17
Recommendations	25
Appendices	
Appendix A: Technological Innovations of the Toyota FX-1	27
Appendix B: Motor Vehicle Certification Examination Results	33
Appendix C: Organization of Automotive Mechanics Technology Curricula by Proficiency Level	35
Footnotes	39

PART I: INTRODUCTION

Since the development of the first "horseless carriages" in Europe and the United States in the late 19th century, the automobile has undergone countless mechanical and technical refinements. Automatic transmission, power steering and brakes, electric starters, automatic chokes, unitized body and body-on-frame construction, safety glass windshields, tubeless tires, sealed-beam headlamps--these are just a few of the innovations that have been introduced over the years to meet consumer demand for improved performance, comfort, and reliability.

During the 1960s and 1970s the pace of technological change and innovation in automobiles accelerated markedly in response to a variety of circumstances. Concerns about dwindling fossil fuel resources, the increasing cost of gasoline and raw materials used in the construction of automobiles, environmental pollution, and the number of motor vehicle-related deaths and injuries prompted manufacturers worldwide to embark on intensive efforts to design and produce cars that were smaller, safer, more fuel efficient, and less polluting. These efforts, often mandated and enforced by local or national governments, involved multi-billion dollar research and development programs and the retooling of entire industries.

As the 1980s began, many industry experts predicted that the automobile would undergo even greater changes in this decade. E. M. Estes, President of General Motors Corporation, commented that "the decade ahead will be one long heyday for technical people in our business--engineers, researchers, and scientists. They may never again have such an opportunity to introduce so much change and innovation."¹ In particular, automotive industry spokespersons cited the increasing use of microelectronic componentry to control engine, drivetrain, and braking functions as a trend that might ultimately revolutionize the car.

Many industry analysts have pointed out that because of the rapidly changing technical characteristics of the car, the occupation of automobile mechanic is undergoing equally great transformation. As one writer has stated, "The traditional mechanic is fading into American history as high-tech automobiles force wrench monkeys to learn more and become technicians.... It used to be that a talented car mechanic could learn repairs by diagnosing with his senses--taking the auto apart, seeing what was broken and fixing it. As more computers, electronics, sensors and other complex systems are put in cars the mechanic has to become more sophisticated in his approach."²

To ensure the continuing responsiveness of vocational and job training programs to employer needs, educators have become increasingly interested in understanding the impact of new technologies on the automobile repair industry. How will these innovations affect the demand for automobile mechanics? What are the implications of these developments for the way in which automobile mechanics are educated and trained? What steps can secondary and postsecondary institutions take to meet the needs of a changing automobile repair industry?

The subject of this report is Hawaii's automobile repair industry. In particular, the discussion focuses on the impact of new technologies on the occupation of automobile mechanic. The report consists of four parts:

1. A description of the ways in which selected technological innovations are affecting the automobile;
2. A summary and analysis of automotive mechanics technology education and training opportunities, employment projections, and certification/registration procedures in Hawaii;
3. The findings of interviews conducted with automotive industry professionals in Hawaii including employers, postsecondary instructors, and high school teachers;
4. Recommendations.

PART II: THE IMPACT OF TECHNOLOGY ON AUTOMOTIVE DESIGN AND ENGINEERING

This section examines the impact of new technologies on automotive design and engineering. The discussion consists of (i) an examination of the effect of computers and other electronic componentry on the automobile; and (ii) a summary of the new and innovative features incorporated in the Toyota FX-1, a developmental car which represents the "leading edge" of Toyota technology.

A Computer in Your Car¹

Recent advances in computer technology, particularly the development and perfection of microprocessors, may revolutionize the automobile by permitting the electronic control of many engine, drivetrain, and braking functions that were previously controlled by relatively inefficient mechanical devices or by drivers themselves. According to some industry analysts, 80 percent of all cars serviced in the U.S. in 1985 will employ one or more microprocessors to control a variety of automotive functions. Whereas the average 1975 car contained about \$6 worth of microprocessors, the average 1985 car is expected to contain about \$240 worth of such devices. The total value of all electronic equipment on these cars will be considerably higher. For instance, the 1980 Lincoln Continental Mark VI contained about \$1,800 worth of electronic componentry, slightly less than ten percent of the car's retail price.

A typical automotive computer is housed in a book-size unit that includes circuit boards connected to the microprocessor(s) and to external devices called sensors. The sensors, located at critical points in the car, provide the microprocessors with information on such variables as the onset of engine knock; exhaust gas oxygen content; barometric and manifold pressures; engine coolant, air, and air/fuel-mixture temperatures; throttle position; engine rpm; exhaust gas recirculation (EGR) valve position; road speed; and brake pressure. The microprocessors are programmed to use this information to control ignition timing, idle speed, air/fuel mixture ratio, EGR valve positioning, air pump and other emission system operations, and transmission shifting through electrical motors and solenoid switches.

Electronic control of certain automotive functions has been available for many years. For instance, electronic fuel injection, first offered by American Motors Corporation on its 1956 Rambler Rebel, was available on 43 production cars in the U.S. in 1982. However, the ability of microprocessors to store and analyze increasingly large amounts of information means that on-board computers are able to monitor more variables and regulate a greater number of automotive functions than was previously imaginable. Ford's Electronic Engine Control, an on-board computer introduced in 1978 and now in its third generation of refinement, controls air/fuel ratio, ignition timing, exhaust gas recirculation, the flow of air from an air pump to either or both sections of the catalytic converter, and the purging of the evaporative

emissions collecting canister, all at the rate of 30 times per second. A fourth-generation system will control even more functions at considerably greater speed.

The role of electronic componentry in cars is not limited to that of regulating engine and emission system functions. Indeed, most industry analysts believe that by the turn of the century almost every facet of the automobile will have been affected by electronics. Some innovative technologies already available on production cars or under development are described below.

- Computer control of automatic transmission shifting is offered on certain Toyotas and is being developed by other manufacturers as well. A major advantage of these systems is that the computer can give the driver shift program choices appropriate for the kind of driving being done (e.g., for maximum power or for getting the best mileage in city driving) and can alter the program for extraordinary driving circumstances such as uphill or downhill driving, full passenger load and/or truck, etc.
- Sophisticated electronic componentry is at the heart of many new automotive safety devices. Computer-controlled anti-skid braking systems "read" incipient wheel lockup and pump the brakes up to 15 times per second, bringing the car to a halt while avoiding potentially dangerous skidding. Several manufacturers are developing radar or sonar systems that will continuously scan a field ahead of the car and warn the driver of unseen obstacles and obstructions. Complex computer programming will enable these systems to distinguish between real obstructions and, for instance, objects at the outside of a normally negotiated curve. Other computerized safety devices include systems that control wheelspin during acceleration and that automatically deploy airbags and tension seatbelts in the event of a crash.
- Electronics is also radically transforming automotive instrumentation. LED (light emitting diode) and LCD (liquid crystal display) instrument display technologies are already widely available. A German firm is working on vacuum fluorescence displays, which present information in the form of colored graphics. However, electronics is not only affecting the way in which information is displayed, but also the type and amount of information that can be made available to the driver. On-board computers developed by General Motors, Ford, Chrysler, BMW, and many other manufacturers are able to warn drivers about open doors, engine overheating, low oil pressure, brake fluid loss, low tire pressure, low-beam headlight failure, tail-lamp or brake-lamp failure, and other critical matters; calculate current miles-per-gallon fuel efficiency and trip average fuel efficiency; inform the driver when upshifting would deliver the same power more efficiently; calculate service intervals taking into account how the car is actually being driven; perform

routine diagnostic procedures to aid the driver or service mechanic in locating sources of trouble, etc.

Because of the enormous information storing and processing capabilities of on-board computers, a major challenge facing manufacturers will be to avoid overwhelming motorists with data and statistics and distracting their attention from the road. The trend in the industry is to distinguish between three "levels" of information in designing instrument panels:

(1) information that should be continuously displayed such as vehicle speed, engine rpm, and fuel; (2) information that should be continuously updated and available but displayed only on driver demand (e.g., miles-per-gallon fuel efficiency); and (3) information that should be automatically but not continuously displayed such as brake fluid loss or low tire pressure.

- A German manufacturer has developed an electronically controlled power-assisted steering system called Servotronic that modulates steering assistance in response to vehicle speed. The advantage of this technology is that it provides the driver with better road feel at high speeds than is possible with direct hydraulic feedback systems.
- Electronic navigational systems are being rapidly perfected by many auto manufacturers. In Japan, Nissan already offers the Drive Guide. It accepts information from the driver about where turns should be made along a predetermined route and then signals when it is time to do so. Ford and General Motors are developing navigation systems that communicate with a satellite to pinpoint the car's location. Honda's navigational system, Electro Gyro-Gator, displays maps on a small video screen and traces the car's progress along the roads with luminous dots.

Toyota FX-1

Although the increasing use of on-board computers and electronic componentry is one of the most significant trends in automotive engineering, technological innovation is affecting the car in many other ways. The extent of technological impact on automotive design and engineering is illustrated by some of the innovations incorporated in the developmental Toyota FX-1. A description of other FX-1 innovations is contained in Appendix A.

I. Styling/Body

- Aerodynamic Cooling Air System

A duct cooling air system takes the shortest path possible from the engine air intake port in the front bumper to the slitted air exhaust louvers over the engine to reduce resistance. A grille shutter behind the front duct and a slide shutter at the back of the hood can be opened and closed freely to adjust engine temperatures.

II. Engine/Transmission

- Twin Turbochargers with Intercooler

Each set of three pistons is equipped with a newly developed, small turbocharger with low turbine inertial mass. This increases the turbo effect at low speeds and improves the transient response. The exhaust manifold is also divided to reduce exhaust resonance and make effective use of the exhaust energy. The air-cooled intercooler improves intake efficiency which, in turn, improves high-speed performance.

III. CHASSIS

- Electronic Modulated Hydropneumatic Suspension

The FX-1 uses hydropneumatic springs instead of conventional steel coil springs. The suspension also automatically adjusts vehicle height to match speed and road conditions. The Toyota Electronic Modulated Suspension (TEMS), first introduced in the domestic SOARER, featured shock absorber damping force control. The FX-1 system takes the concept one step further by also controlling the suspension spring rate. The suspension automatically adjusts itself to enhance both comfort and handling, whether starting out, cornering, or braking. Manual control lets the driver set the shock absorber damping force and suspension spring rate to either soft or hard.

The seven levels of the system are: LOW, NORMAL, HIGH, NOSE UP, and TAIL UP for normal running, and EXTRA LOW and EXTRA HIGH for tire changing.

IV. Electronics

- Color CRT Display

All kinds of information can be called up as needed and displayed on a six-inch color CRT display. This CRT works on the same concept as that in the space shuttle and on Boeing's newest aircraft, the B767. The CRT displays the operating conditions of the engine and the Electronic Modulated Hydropneumatic Suspension System on an information screen; vehicle speed, engine revs, and self-diagnosis on a prologue screen segment; and various warnings on a warning screen segment, all in accordance with the operating condition of the vehicle.

V. New Materials

- FRM Connecting Rod

FRM is a fiber-reinforced metal compound made of alumina fiber and aluminum alloy. It is light, rigid, and very strong. FRM may become very important in future engineering. There are two examples of its use so far: first as a structural material for the space shuttle; second as part of Toyota's ceramic fiber alloy piston. Now Toyota's FX-1 has FRM connecting rods.



Instruction in automotive mechanics technology is provided by 35 public high schools and 6 University of Hawaii community colleges. The widespread availability of AMT programs is indicative of their popularity among students for both vocational and avocational purposes.



The increasingly complex nature of the modern car means that mechanics must often use sophisticated troubleshooting equipment to diagnose the cause of vehicle malfunction. Automotive service industry employers emphasized the importance of training in the use of advanced testing instruments such as the computerized engine analyzer picture above.

PART III: LABOR SUPPLY AND DEMAND

Education and Training Opportunities for Automotive Technicians

Instruction in automotive mechanics technology (AMT) is provided by numerous public and private institutions and organizations in Hawaii. The widespread availability of AMT programs is indicative of their popularity among students for both vocational and avocational purposes.

- At the secondary level, courses in power and automotive technology are offered at 35 out of 39 public high schools (including Olomana, the Hawaii Youth Correctional Facility school) on the islands of Oahu, Hawaii, Maui, and Kauai. The Department of Education's Authorized Courses and Code Numbers guide identifies and describes two Industrial-Technical (IT) Program courses that pertain to this area:¹
 - Power and Automotive Technology I (Code #VI61). Organized experiences in the design and function of power systems employing various types of engines and mechanisms involved in the development, transmission, and control of power. Emphasis is placed on basic entry-level job skills in automotive repair and service.
 - Power and Automotive Technology II (Code #VI63). Classroom and shop experiences which include training in all phases of automotive maintenance repair work on all types of automotive vehicles. Included is training in the use of technical manuals and a variety of hand and power tools. Instruction and practice are provided in the diagnosis of malfunctions, disassembly of units, parts inspection, and repair or replacement of parts involving the engine, ignition system, carburetor, brakes, and transmission. Simulated class experiences and on-the-job experiences are involved.

According to Vocational Education Data System (VEDS) statistics, 1,417 public secondary students were enrolled in automotive mechanics courses during July 1982 - June 1983. Approximately 97 percent of these students were males and 3 percent were females. Classroom instruction and on-the-job training in automotive mechanics is also provided by the Hawaii Job Corps Center, a residential vocational training school for disadvantaged youth aged 16 to 21 years.

- At the postsecondary level, AMT programs leading to the Associate in Science degree (AS), Certificate of Achievement (CA), or Certificate of Completion (CC) are offered at six University of Hawaii community colleges: Hawaii Community College (AS, CA), Honolulu (AS, CA), Kauai (AS, CA), Leeward (AS, CA, CC), Maui

(AS, CA), and Windward (CA, CC). Each of these programs provides comprehensive instruction in the maintenance and repair of automotive engines, fuel, ignition, brake, steering and suspension systems, manual and automatic transmissions, and other major components and devices. VEDS statistics indicate that 943 students were enrolled in community college AMT courses during 1982-83. Approximately 96 percent of these students were males and 4 percent were females.

Postsecondary level AMT instruction is provided by three other institutions in Hawaii:

- The New York Technical Institute, a private trade school located in Honolulu, offers an automotive mechanics program consisting of 1,500 hours of classroom and shop instruction. The Institute reports that over 100 students are enrolled in this program in any given year.
- The University of Hawaii Employment Training Office (ETO) offers a 35-week, open-entry/open-exit training program in automotive mechanics for students referred from other agencies and the general public. In FY 1982, 132 trainees participated in the automotive mechanics program. ETO also offers a college credit program in automotive technology for Armed Forces personnel in conjunction with Honolulu and Leeward community colleges. The program served 273 participants in FY 1982.
- Brigham Young University-Hawaii offers an Associate degree and a two-year certificate in automotive technology. In addition, a B.S. degree in Industrial Education with emphasis on automotive technology is available for students who intend to pursue a teaching career at the intermediate or secondary levels.
- Apprenticeship programs in automotive technology are offered by such major employers as Hawaiian Electric Company and the sugar plantations. The Apprenticeship Division, Department of Labor and Industrial Relations, reports that 27 employers have established apprenticeship agreements with the department in automotive mechanics and that 18 have established apprenticeship agreements in service mechanics.

Employment Projections

Because automotive technology training programs are so numerous, the supply of entry-level automotive mechanics in Hawaii is more than sufficient to meet employer needs. For instance, projections developed by the Office of the State Director for Vocational Education (OSDVE) indicate that the annual output of automotive mechanics from DOE high schools, U.H. community colleges, private institutions, apprenticeship programs, and other sources will exceed employers' yearly needs during 1983-87.²

As indicated by the chart on the following page, OSDVE consolidates its supply projections and labor surplus/deficit estimates for auto body repairers and auto mechanics. However, assuming that the supply of auto body repairers and auto mechanics will be proportionate to anticipated employment in these two occupations, it can be inferred from the OSDVE data that the supply of auto mechanics will substantially exceed demand in each year during 1983-87.³

OSDVE LABOR SUPPLY AND DEMAND PROJECTIONS

Instructional Program	Anticipated Employment	Projected Demand	Projected* Supply	Surplus (+) Deficit (-)
<u>1983</u>				
Auto Mechanics	7,645	313	566	+207
Auto Body	1,370	46		
<u>1984</u>				
Auto Mechanics	7,887	362	572	+154
Auto Body	1,398	56		
<u>1985</u>				
Auto Mechanics	8,084	320	577	+209
Auto Body	1,418	48		
<u>1986</u>				
Auto Mechanics	8,295	337	580	+196
Auto Body	1,437	47		
<u>1987</u>				
Auto Mechanics	8,490	324	583	+214
Auto Body	1,453	45		

*For 1983 and 1987, the OSDVE provides the following breakdown of labor supply by source:

	<u>1983</u>	<u>1987</u>
DOE	194	202
Community Colleges	195	204
CETA	65	65
Private Schools	33	33
Apprenticeship	<u>79</u>	<u>79</u>
TOTAL	566	583

The OSDVE statistics show that total employment of automotive mechanics in Hawaii is expected to increase approximately 11 percent during 1983-87, from 7,645 to 8,490. To fill these 845 new positions and replace those who will retire, quit, migrate out of state or for other reasons leave their jobs, the OSDVE estimates that 1,656 auto mechanics will be required.

In comparison with the OSDVE projections, the State Department of Labor and Industrial Relations (DLIR) forecasts an 18 percent increase in employment of auto mechanics in Hawaii during 1980-90 and the U.S. Bureau of Labor Statistics (BLS) forecasts a national increase of 24.25 percent during 1978-90.⁴ Each of these employment projection models - OSDVE, DLIR, and BLS - indicates that the growth rate for auto mechanics will closely approximate the average growth rate for all occupations considered in the respective surveys. Thus, the number of automotive mechanics jobs will steadily increase in the years ahead, but the occupation will not experience the dynamic growth that has been predicted for data processing machine repair, computer systems analysis, office machine servicing, computer programming, and certain other technical/mechanical occupations.

Motor Vehicle Mechanics Certification and Registration

Although OSDVE projections indicate that there is a surplus of entry-level automotive mechanics in Hawaii, the State Department of Labor and Industrial Relations identifies automobile mechanic as a demand occupation (i.e., an occupation that has a shortage of workers) both on Oahu and Maui.⁵ To understand this apparent anomaly, it is necessary to consider the Hawaii motor vehicle mechanics certification process.

Chapter 437B, Hawaii Revised Statutes (Act 143, SLH 1975), establishes a Motor Vehicle Repair Industry Board (MVRIB) within the Department of Commerce and Consumer Affairs (DCCA) and sets forth procedures for the certification and registration of motor vehicle mechanics in Hawaii. As stated in the preamble to Act 143, the purpose of the motor vehicle mechanics certification program is to ensure the provision of "quality automotive repair services to the motoring public."

To become a certified motor vehicle mechanic in Hawaii, a person must first successfully complete at least 1-2 years of schooling in automotive repair and/or 1-3 years of experience under an intermediate, journeyworker, registered, or registered-certified mechanic in the specialized area for which certification is desired (a list of these specialties is given below). The rules and regulations implementing Chapter 437B cite five possible combinations of education and experience that fulfill the requirements for certification.

Having completed these requirements, a person is eligible to take the Hawaii Motor Vehicle Mechanic Certification Examination. The examination, administered by the Office of the State Director for Vocational Education, consists of both a written test and a performance

test. There are ten areas of specialization of which eight are automotive: engine, tune-up, automotive transmission, brakes, electrical systems, front suspension and wheel alignment, air-conditioning, and standard transmission/rear axle. The two other specialties are diesel engine and motorcycle/motor scooter.

A person who passes the written and performance tests in any one of the areas listed above becomes a certified motor vehicle mechanic in that specialty. Candidates may take the certification examination in more than one area. A person who passes the test in all eight automotive specialties becomes a certified general mechanic. A summary of motor vehicle mechanic certification examination results is provided in Appendix B.

Upon certification, the examinee is entitled to register with the MVRIB as a motor vehicle mechanic. Chapter 437B makes special provisions for the registration of those who worked as mechanics prior to the enactment of this statute. Under Section 437B-24, a person who worked as a mechanic for at least two years prior to January 1, 1976 could apply for registration until June 30, 1976 without taking the certification exam. Thus, the law distinguishes between a "certified mechanic" (one who has passed the written and practical certification tests and registered with the MVRIB) and a "registered mechanic" (one who, on the basis of experience gained prior to 1976, registered with the MVRIB without taking the certification exam).

It is important to note that a person may engage in the repair of motor vehicles for compensation without being either a certified or a registered mechanic. However, these personnel must work under the supervision of a certified or registered mechanic. A repair dealer might employ a mechanic certified in automotive tune-up to supervise a crew of workers engaged in this specialty, another mechanic certified in brakes to supervise brake repairers, etc.

Statistics maintained by the State Department of Commerce and Consumer Affairs, Professional and Vocational Licensing Division, show the total number of motor vehicle licensees since the enactment of Chapter 437B, HRS.

	<u>Certified</u>	<u>Registered/Certified*</u>	<u>Registered</u>
1976	-	-	-
1977	-	-	-
1978	-	-	4,848
1979	21	20	4,847
1980	62	32	4,381
1981	124	43	3,860
1982	174	45	3,985
1983	228	48	3,977
1984	311	49	3,472

As these figures indicate, 4,848 mechanics in Hawaii were originally exempted from taking the certification examination on the basis of work experience gained prior to 1976 and accorded the status of registered mechanic. Since 1978 the number of registered mechanics has dropped from 4,848 to 3,472 due to retirements, career changes, deaths, and other factors. During the same period, DCCA statistics show that 311 mechanics passed one or more of the ten motor vehicle certification examinations and attained the status of certified mechanic.

Automotive industry and employment professionals point out that the supply of certified mechanics has been insufficient to offset the decreasing number of registered mechanics let alone to meet employers' labor needs due to business expansion. The result is an increasingly serious shortage of experienced, certified mechanics who are able to work with little or no supervision. For instance, Employment Service spokespersons report that although the number of automotive mechanics job applicants far surpasses the number of jobs listed by employers (see p. 40), employers generally request certified personnel whereas the

*A registered/certified mechanic is one who was originally exempted from taking the certification examination on the basis of work experience gained prior to 1976, but subsequently gained certification in one of the ten specialty areas cited above.

majority of ES applicants are entry-level, noncertified workers. Because of the shortage of certified mechanics, DLIR identifies automobile mechanic as a demand occupation on Oahu and Maui.

In summary, the supply of automotive technicians in Hawaii is characterized by two features: (i) a surplus of entry-level mechanics and (ii) a shortage of experienced, certified mechanics.

PART IV: INTERVIEWS

This section presents the major findings of interviews with automotive technology professionals in Hawaii including repair industry employers, community college instructors, and high school teachers. In particular, interviewees were asked to comment on the impact of new technologies on the education and training of automobile mechanics. Information gained from a review of pertinent resource documents is also cited.

Employers

- When asked about the impact of technology on the automotive service industry, employers stated that although the gasoline or diesel internal combustion engine will be the predominant vehicle power plant for the foreseeable future, cars will become more complex, sophisticated, and expensive to repair. In terms of the implications of technological advancement for the knowledge and skills needed by automobile mechanics, employers made the following points:

- Employers noted that the increasing complexity of the automobile and the rapid rate at which technological innovations are being introduced mean that automotive technicians must absorb greater amounts of information than in the past. One interviewee noted that the engine diagnostic instructions in a typical repair manual had grown from 56 to 200 pages in a single year (1981-82) and attributed this to the increasing use of on-board computers in cars.

Because of the wealth of information that automotive technicians are being called upon to master, employers emphasized that the ability to read and comprehend complex material is one of the most valuable skills that these workers can possess. Several employers stated that one of the most common deficiencies of entry-level mechanics is their inability to read and comprehend well.

- The increasingly complex nature of the modern car also means that employers are placing added emphasis on the mechanic's skill in diagnosing the cause of vehicle malfunction. Interviewees pointed out that whereas the inexperienced mechanic was once able to diagnose the cause of vehicle malfunction by disassembling the car, locating the broken part and fixing it, this approach can result in extensive damage to today's high-tech automobile. As one employer stated, "You can't go in and poke around anymore. Using the wrong voltmeter could ruin a sensor, or getting a wrong voltage on a wire can ruin a computer."

To enhance the level of diagnostic skills among prospective automotive technicians, employers emphasized the importance of training in the use of such troubleshooting instruments as volt-ampere testers, oscilloscopes, engine analyzers, and exhaust emission infra-red testers.

- Several employers stated that because the cost of repairing a defective car part often exceeds the cost of a new part, component replacement has gradually replaced component overhaul as standard operating procedure in the context of the modern automotive repair facility. The trend towards component replacement further highlights the importance of the mechanic's analytical and diagnostic skills as opposed to the manual and mechanical aptitudes often associated with the occupation.
- All employers emphasized the importance of a sound knowledge of automotive electrical/electronic systems, particularly in view of the growing number of on-board computers. However, employers stated that auto technicians will not have to become electronics experts to work on the modern, computerized car. As in the case of many other complex automotive components, if a car's computer has a serious defect that cannot be dealt with on an in-house basis, the devices may simply be replaced by new ones and returned to the manufacturer for repair.
- One employer speculated that the automotive service industry would gradually develop a systematic distinction between automotive mechanics and automotive technicians. Under this system, the technicians would be responsible for diagnosing the cause of vehicle malfunction and issuing instructions to the mechanic who would be responsible for correcting the problem.
- Representatives of the larger, unionized automotive repair businesses state that they rarely hire mechanics directly from postsecondary institutions. These employers pointed out that the relatively high wages earned by union mechanics usually make it possible to recruit experienced workers to fill job vacancies. The best sources of entry-level positions for recent AMT graduates are the smaller, nonunionized shops whose wage scales are usually much lower than those of their unionized counterparts. Car rental firms appear to be another good source of jobs for AMT graduates. Because these firms deal with newer automobiles, major mechanical problems that might be beyond the capabilities of the entry-level worker are less likely to occur.
- An industry opinion survey conducted by Honolulu Community College in 1973 indicated that the automotive service industry in Hawaii provides fewer on-the-job training opportunities (i.e., apprenticeship or in-service training) than other industries.¹

AMT employers and educators interviewed for this needs assessment believed that the relative lack of on-the-job training opportunities is still a characteristic of the automotive service industry. Out of 38 AMT employers surveyed in the HCC study, 55.3 percent stated that they did not offer any type of on-the-job training. By contrast, the percentage of employers in other industries who did not offer on-the-job training were 26.3 percent (Heavy Equipment Maintenance and Repair), 15.4 percent (Aviation Maintenance Technology), 16.0 percent (Electronics Technology), 11.8 percent (Industrial Electricity), and 6.3 percent (Refrigeration and Air Conditioning). Among the 13 industries considered in the Honolulu Community College survey, AMT ranked next to last in terms of the percentage of employers offering on-the-job training.

- The lack of on-the-job training opportunities in the automotive service industry may be related to the fact that the industry is composed of an exceptionally large number of small firms that employ only 1-12 mechanics. According to the 1973 Honolulu Community College study, 63.1 percent of AMT employers surveyed maintained a staff of 1-12 mechanics while only 23.7 percent employed more than 25 mechanics.² In aviation maintenance technology, on the other hand, only 7.7 percent of the firms reported that they employed 1-12 mechanics while 61.5 percent reported employing over 25. Small firms of the sort that characterize the automotive service industry often lack the personnel and financial resources to develop and operate on-the-job training programs.
- Interviews with employers confirmed that in-service training for entry-level technicians is a major problem in the automotive service industry, particularly in a time of rapid technological innovation. Many AMT graduates secure their first jobs with small, privately-owned shops, garages, etc. However, these are precisely the firms that are least apt to have the resources needed to provide structured in-service training opportunities for their employees. As a result, the ability of the entry-level workers to gain knowledge and skills that will enable them to advance to the intermediate or journey level is seriously hampered.
- One major Honolulu dealership reported on a new way of organizing its service operations that has important training implications. The employer noted that the technological complexity of the modern car has created a need for mechanics who are specialists in a particular automotive system. Although some mechanics, particularly in small businesses, still function as generalists, those in larger companies are usually classified as brake mechanics, transmission mechanics, tune-up specialists, etc.

The employer stated that most cars brought in for repair require the attention of two or more specialists. Under its old operating procedures, the car would be serviced by a succession of mechanics, each of whom worked independently of the others. The major drawback of this system is that excessive amounts of time are devoted to scheduling and coordinating the activities of mechanics.

Under its new system, mechanics are grouped into five-member teams that possess expertise over the full range of automotive specialties. A car brought in for servicing is assigned to a specific team which carries out all of the necessary repairs. The logistical problems associated with the old system are thereby reduced to a minimum.

Besides being versed in different automotive specialties, the members of these teams represent various skill levels, from mechanic's helper to group captain. Because the tasks involved in any given repair job are of varying degrees of complexity, it makes good economic sense to have the simplest of these performed by relatively low-paid helpers while reserving the journeyworker's time and energies for complex procedures.

Employers emphasize that this system is becoming popular because it increases productivity and decreases costs, but it has the added effect of creating on-the-job training opportunities for entry-level workers. Put simply, the team concept provides a meaningful work role for entry level mechanics whose skills are not sufficient to permit them to work independently and brings them into direct contact with other mechanics from whom they can learn.

Postsecondary Level

- AMT is a popular program at the community colleges and students must often wait at least two semesters before being able to take courses in the subject. However, instructors point out that many AMT majors do not intend to pursue careers in the automotive service industry. Instructors hypothesize that students who are undecided about their vocational objectives are more likely to enroll in AMT than in some other programs because of the likelihood that they can use the knowledge and skills they gain for avocational purposes. Estimates differ, but some instructors believe that about 50 percent of AMT majors intend to pursue careers in the industry. Instructors stated that it is important to recognize and address the varying needs and interests of AMT majors.
- Although community college AMT curricula vary, on all campuses the courses or sequences of modules focus on the major automotive systems (e.g., engine, fuel, electrical, etc.). Under this

subject-matter method of presentation, a course or sequence of modules on automotive fuel systems will cover topics ranging from the simple to the complex. As students progress through the program, they are introduced to additional automotive systems and, in each course, will be taken from the fundamentals of that system to more advanced diagnostic and repair procedures.

- A major concern of AMT instructors is to maintain and improve the credibility of community college AMT programs among employers. In particular, instructors point out that the subject-matter method of organizing the AMT curriculum sometimes makes it difficult for employers to gauge the skill level of AMT graduates. One suggested approach is to organize AMT curricula by proficiency levels (see Appendix C).
- The 1973-74 Hawaii Articulation Institute AMT team emphasized the importance of vertical articulation between the high schools and community colleges and recommended that the community colleges establish procedures for challenging courses. Although such procedures have been instituted, community college instructors report that it is very rare for a high school graduate to successfully challenge an AMT course. Most instructors could not cite any instances of a student who received credit by examination.
- Many AMT instructors believe that the motor vehicle mechanics certification process should be revised. Under the rules and regulations implementing Chapter 437B, HRS, a person who has successfully completed a two-year community college AMT program must gain at least one year's work experience before being able to take the written portion of the certification exam. However, instructors argue that this work experience requirement is too rigid. They point out that the Federal Aviation Agency allows prospective aviation mechanics to take the written and performance portions of its certification exam immediately after graduating from an accredited two-year aviation maintenance technology (AVMAT) program, despite the fact that AVMAT is generally considered to be a more specialized field than AMT. These instructors believe that by allowing AMT students to take at least the written portion of the motor vehicle mechanics certification exam immediately after graduating, advanced, industry-bound graduates would be able to provide further evidence of their proficiency that would help them in securing an entry-level position.
- AMT program reviews conducted by the community colleges cite the need for increased in-service training for instructors to enable them to keep abreast of changes and innovations in automotive technology. One recent review recommends the establishment of a regular schedule of workshops during semester breaks and summer months and the provision of a semester-long work/study leave with pay every 2-3 years for instructors.

Secondary Level

- As expressed in the State Master Plan for Vocational Education, the major purpose of secondary-level vocational programs is to provide students with basic, entry-level job skills in broad clusters of occupations, rather than specialized and more advanced skill training. High school automotive technology teachers noted that the increasing technological complexity of automobiles has made it difficult for high school graduates to secure entry-level positions in the automotive service industry and therefore that the role of high school automotive programs as presented in State planning documents is an appropriate one. However, many teachers emphasized that technological advances in automotive engineering mean that the service industry will need mechanics who are more knowledgeable and skilled than in the past. To meet this need, it may become necessary for high school programs to equip industry-bound students with a higher level of expertise on which to build during their postsecondary training. Thus, although preparation is the primary mission of high school automotive programs, technology may have a significant influence on the content of the secondary AMT curriculum.
- Teachers reported that many automotive program completers who do not continue their educations secure jobs as gas station attendants. Teachers regarded this as, at best, an uncertain avenue of approach to the automotive service industry. Although some gas station attendants who show initiative and enthusiasm are given light maintenance and repair responsibilities by their employers, these cases appear to be the exception rather than the rule. All high school teachers interviewed said that they advise students interested in a career in automotive mechanics to enroll in community college or apprenticeship programs.
- A 1974 content identification and validation survey conducted by the Office of Instructional Services, DOE, asked automotive service industry employers to identify subjects that a high school auto program should cover.³ Generally speaking, the subjects that received the highest ratings were of a theoretical rather than a practical nature. For instance, while 52 percent of the survey respondents stated that it was very important for a high school program to cover the fundamental principles of carburetors, only 19 percent thought that carburetor overhaul was a very important topic for the high school curriculum. Similarly, 57 percent thought that it was very important for high school programs to provide information on the sources of pollutants and the evolution of clean air systems in cars, but only 29 percent stated that the servicing of these systems was a very important part of the high school curriculum. Practical repair procedures that received the highest "very important" rating from survey respondents were of a relatively simple nature such as replacing oil filters (57 percent), replacing spark

plugs, wires, points, and other ignition parts (57 percent), lubricating chassis (52 percent), testing and charging batteries (52 percent), draining and refilling automatic transmission fluid (43 percent), etc.

- According to the 1974 DOE survey, employers believe that the high school automotive curriculum should concentrate on providing exploratory and preparatory experiences. However, the survey also indicates that many employers want and/or expect the high school programs to impart more sophisticated repair and overhaul skills. This is demonstrated by the substantial percentage of employers who stated that the following subjects are a very important part of the high school curriculum.

<u>Subject</u>	<u>Percent Indicating Very Important</u>
Replace piston and piston rings	19%
Overhaul one-barrel and two-barrel carburetors	19%
Overhaul starting motors	14%
Overhaul wheel and master cylinders	29%
Overhaul disc brake assemblies	19%
Overhaul cylinder head assembly	14%

- High school teachers interviewed stated that, given the proper equipment and facilities, the industry-bound student could be brought to a higher level of proficiency than is now the case. Realizing that fiscal constraints make it unfeasible to attempt to substantially upgrade all, or even most, high school automotive programs, one teacher suggested upgrading a single program in each district and designating it as an advanced training center for qualified automotive technology students in that district.
- To provide students with more advanced knowledge and skills in automotive technology, some teachers make extensive use of individualized, self-study courses. At one high school, students are offered the following sequence of year-long courses. At the vocational exploratory level, Automotive Mechanics I and Research and Development courses (Industrial Arts) are offered and at the vocational preparation level, Power and Automotive Technology I and Power and Automotive Technology II courses (Industrial

Technical) are given. The Research and Development courses give highly motivated students an opportunity to work on projects of their own choosing and provide them with additional shop experience and exposure to a wider variety of automotive troubleshooting and repair procedures.

RECOMMENDATIONS

1. The Council recommends that the State Board for Vocational Education request the University of Hawaii to conduct curriculum content identification and validation surveys of automotive service industry employers in order to reflect recent technological innovations in the field.
2. The Council recommends that the State Board for Vocational Education request the Department of Education to utilize the Area Vocational Center concept, individualized self-study courses and other instructional strategies to provide qualified and interested high school automotive technology students with an opportunity to gain advanced diagnostic, repair, and servicing skills.
3. The Council recommends that the State Board for Vocational Education request the University of Hawaii to:
 - a. Establish a committee to consider the status of horizontal articulation among community college AMT programs with special reference to the impact of technology on course content.
 - b. Consider developing alternative curricular methods that better meet employer needs in delivering automotive mechanics training (e.g., programs that provide employers clearer descriptions of the job skill levels attained by students).
4. The Council recommends that the Motor Vehicle Repair Industry Board, Department of Commerce and Consumer Affairs, amend the rules and regulations implementing Chapter 437B, Hawaii Revised Statutes, to eliminate the requirement that graduates of a two-year AMT program gain at least one year's work experience before taking the written portion of the motor vehicle mechanic certification examination.

APPENDICES

APPENDIX A

Technological Innovations of the Toyota FX-1

In addition to the technical features of the Toyota FX-1 cited in Part II of the study, this developmental automobile incorporates the following innovations:

I. Styling/Body

- Body Surface

The FX-1 has no unnecessary protrusions to mar its body construction. Features include: A crystal canopy with glassed-in pillars; fully-concealed windshield wipers with slide shutter; completely flush body surface; flush underbody cover; dual streamline shape body for better aerodynamic properties.

- Tilt & Glide Door

The Tilt & Glide door opens exceptionally wide making the car easy to get in and out of, despite its highly aerodynamic shape.

- Color-coordinated Rear Combination Lamps

In daylight, the panels covering the rear combination lamps are the same color as the rest of the body, but when braking or when turned on at night, they become extra-large, easy-to-see lamps: the brake and tail lamps red and the turn signals orange.

II. Engine/Transmission

- Twin Cam 24-valve Engine

This engine is based on the twin cam 24 valve IG-GEU that won the 1982 JSME medal for technology from the Japan Society of Mechanical Engineers. It attains a high level of output while maximizing the traditional smoothness and quietness inherent in the inline six-cylinder engine design.

- Variable Valve Timing Camshafts

An electronic system controls the intake and exhaust camshafts separately to create optimum intake and exhaust valve timing and overlap across the whole engine speed range, low to high. This assures both high engine output and low fuel consumption.

In this system, the step motor moves the slider along the inner and outer sleeve groove in a horizontal direction. The inner sleeve, which is at the front end of the camshaft, rotates up to ten degrees within the outer sleeve as the slider moves, effectively controlling the valve timing.

- Acoustic Induction Control System

The intake manifold is divided into the 1-2-3 piston and the 4-5-6 piston groups, using intake pulsation to produce a high intake efficiency characteristic "A."

There is a control valve located between these two intake systems. Opening the valve changes the acoustic characteristics of the intake system and causes an intake characteristic "B." The control valve opens or closes to select the "A" or "B" intake characteristics automatically, to match the engine's operating conditions. Thus the Acoustic Induction Control System promotes high intake efficiency across the engine speed range.

- Modulated Displacement System

This system improves fuel consumption by shutting down some of the pistons and running the vehicle on the remaining pistons when it is idling or running at light load. The shutdown method is quite simple: fuel and airflow to the 4-6 piston group is cut off and exhaust gases flow back into the shut-down pistons. The method is extremely reliable because of its simplicity, and it maintains high performance as well. It also improves fuel economy by more than ten percent.

- Distributorless Ignition System

This ignition system uses a computer to spark the cylinders instead of the ordinary mechanical high-tension distributor systems.

The computer calculates the optimum ignition point for each cylinder as it receives data on crank angle from an electromagnetic sensor and on intake pressure from a pressure sensor, among others. The computer then commands the ignitor, which in turn sends a primary current through the ignition coil. Here the current is jumped to a high voltage, racing through the high-tension wire to generate a spark in the spark plug.

The three ignition coils, one coil per pair of cylinders, are installed inside the head cover so there are no visible

high-tension wires as in existing distributor systems. This method reduces ignition energy loss and, combined with platinum-tipped plugs, assures reliable ignition and reduces the need for ignition system maintenance.

- Electronically-Controlled Two-Way Overdrive Four-Speed Automatic Transmission (ECT-S)

The two-way overdrive four-speed automatic transmission, which received the 1980 JSME medal for technology from the Japan Society of Mechanical Engineers, was further improved for the FX-1 by adding an electronic control ECT-S system.

The system assures optimum gear selection, matching vehicle operating conditions, and allows the driver to select MANUAL, ECONOMY or POWER modes to suit his or her driving style. The system makes the most of engine and vehicle performance as well as offering smooth gear changes and comfortable operation.

III. Chassis

- Four-Wheel Double Wishbone Suspension

The FX-1, in the tradition of the Toyota 2000 GT, uses a backbone frame and pipe four-wheel double wishbone suspension with unequal arms. The frame is light-weight yet strong and rigid. Extra-wide tread and low-profile 225/50VR tires give excellent anti-roll stability. This means the FX-1 has the under-carriage necessary for a sporty specialty car.

- Four-Wheel ESC

The FX-1 is equipped with computer-controlled four-wheel electronic skid control (ESC) and four-wheel ventilated disc brakes. This system provides safer braking and handling during emergencies, as it prevents wheel lock even on slick roads.

- Speed-responsive Rack & Pinion Steering

A signal from the vehicle speed sensor controls signal current in the solenoid valve, which alters the power-assist ratio progressively according to the vehicle speed--light at low speeds, heavier at high speeds.

IV. Electronics

- Color LCD Meter

Liquid crystal displays show the coolant temperature/oil pressure, voltage/fuel level, shift lever position, ECT-S mode, odometer, and trip meter. The trip meter also acts as a back-up to the speedometer displayed on the CRT. The color LCD meter uses an optical fiber multi-plex communications system.

- Electronic Controlled Tilt & Telescope Steering

A microcomputer automatically tilts both the steering wheel and the meters up when the driver gets in or out of the car. The microcomputer remembers the preferred tilt position and restores the position for the next ride.

- Fixed Steering Wheel Pad Switch

The steering wheel center pad is fixed and does not rotate with the wheel. Various controls and switches needed in the operation of the car are situated on this center pad, close at hand. This switching system gives surer operation.

- Voice Command System

The FX-1's computer recognizes certain voice commands and will supply voice-synthesized information to the driver concerning such things as speed or fuel reserves. Lights and windshield wipers also respond to the driver's vocal commands.

- Digital Audio Disc (DAD)

The FX-1 is equipped with a DAD system, a compact, easy-to-use, super-high-fidelity sound system that is revolutionizing the audio world.

- LCD Automatic Day & Night Mirror

Two light sensors detect the brightness of lights coming up behind the FX-1 and the brightness of the area around the driver and send electronic signals to the liquid crystal cells, automatically adjusting the reflectiveness of the mirror to the proper level.

- Fluorescent License-plate Lamp & Courtesy Lamp

Fluorescent lamps improve both visibility and brightness.

V. New Materials

- R-RIM Bumper & Fender

Compared to existing urethane or steel bumpers and fenders, R-RIM (Reinforced Reaction Injection Molding) urethane is much lighter and of much higher quality. R-RIM is also rustproof. R-RIM is used for bumpers and fenders of the FX-1.

- Ceramic Disc Brake Piston

For the FX-1's disc brake pistons, crystalline glass is used. It is a high-strength ceramic with the lowest weight ratio and a heat conductivity rate only 1/25 that of steel. This lightens the disc brake (these pistons are 30-40% lighter than steel pistons) and improves resistance to vapor lock.

- Shape Memory Effect Alloy (SMEA)

SMEA has been widely talked-about as an important material of the future. Now it is beginning to see use as an automotive component.

The special temperature-modification characteristics of shape memory effect alloy become apparent when used as springs in the grille shutter of the FX-1. The SMEA springs act as actuators and sensors that help control engine compartment temperature by opening and closing the radiator rear duct in reaction to the temperature in the engine compartment.

- Ceramic Cloth Sandwich Exhaust Pipe

The exhaust pipe of the FX-1 incorporates a three-layer heat-cutting ceramic cloth structure between inner and outer pipe walls. This eliminates the need for the protector used in existing exhaust pipes to insulate the cabin floor from the heat build-up of the exhaust pipe. The system also reduces exhaust pipe noise.

- FRP Bumper Reinforcement

The existing steel bumper reinforcement is replaced by FRP. Weight is reduced by 50 percent while the optimum shape obtained by structure analysis and strength is maintained.

- Steel-plastic Laminate Hood

Laminated plate, with plastic film sandwiched between two steel plates, retains the properties of steel at much less weight.

APPENDIX B
MOTOR VEHICLE CERTIFICATION EXAMINATION RESULTS
WRITTEN TEST

	1 AC #P/TOT	2 AT #P/TOT	3 B #P/TOT	4 ES #P/TOT	5 E #P/TOT	6 FS #P/TOT	7 ST #P/TOT	8 TU #P/TOT	9 DE #P/TOT	10 MO #P/TOT
1976	$\frac{22}{33}$	$\frac{4}{33}$	$\frac{74}{166}$	$\frac{19}{42}$	$\frac{30}{85}$	$\frac{21}{52}$	$\frac{15}{43}$	$\frac{35}{109}$	$\frac{4}{7}$	$\frac{2}{4}$
1977	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{30}{58}$	$\frac{6}{14}$	$\frac{11}{33}$	$\frac{10}{23}$	$\frac{1}{8}$	$\frac{20}{36}$	$\frac{0}{5}$	$\frac{1}{3}$
1978	$\frac{29}{42}$	$\frac{25}{35}$	$\frac{108}{208}$	$\frac{41}{111}$	$\frac{54}{160}$	$\frac{50}{89}$	$\frac{16}{47}$	$\frac{62}{159}$	$\frac{1}{11}$	$\frac{8}{20}$
1979	$\frac{13}{26}$	$\frac{13}{21}$	$\frac{56}{96}$	$\frac{20}{41}$	$\frac{36}{85}$	$\frac{17}{29}$	$\frac{7}{25}$	$\frac{26}{74}$	$\frac{0}{0}$	$\frac{1}{8}$
1980	$\frac{13}{25}$	$\frac{11}{24}$	$\frac{61}{100}$	$\frac{17}{34}$	$\frac{32}{80}$	$\frac{29}{55}$	$\frac{12}{23}$	$\frac{28}{69}$	$\frac{1}{6}$	$\frac{11}{18}$
1981	$\frac{17}{30}$	$\frac{19}{30}$	$\frac{55}{103}$	$\frac{15}{43}$	$\frac{31}{65}$	$\frac{19}{44}$	$\frac{6}{3^{\wedge}}$	$\frac{31}{75}$	$\frac{2}{16}$	$\frac{2}{5}$
1982	$\frac{15}{22}$	$\frac{8}{17}$	$\frac{64}{116}$	$\frac{17}{40}$	$\frac{33}{74}$	$\frac{40}{58}$	$\frac{17}{37}$	$\frac{35}{89}$	$\frac{3}{22}$	$\frac{5}{21}$
1983	$\frac{17}{27}$	$\frac{13}{19}$	$\frac{43}{79}$	$\frac{8}{25}$	$\frac{23}{50}$	$\frac{19}{34}$	$\frac{11}{26}$	$\frac{20}{46}$	$\frac{0}{8}$	$\frac{3}{8}$
TOTAL	$\frac{129}{209}$	$\frac{94}{183}$	$\frac{491}{926}$	$\frac{143}{350}$	$\frac{250}{632}$	$\frac{205}{384}$	$\frac{85}{239}$	$\frac{257}{657}$	$\frac{11}{75}$	$\frac{33}{87}$

PRACTICAL TEST

	1 AC #P/TOT	2 AT #P/TOT	3 B #P/TOT	4 ES #P/TOT	5 E #P/TOT	6 FS #P/TOT	7 ST #P/TOT	8 TU #P/TOT	9 DE #P/TOT	10 MO #P/TOT
7/79 - 12/81	$\frac{31}{50}$	$\frac{19}{31}$	$\frac{124}{385}$	$\frac{48}{110}$	$\frac{67}{162}$	$\frac{54}{83}$	$\frac{7}{12}$	$\frac{71}{129}$	-	-
1/82 - 12/82	$\frac{17}{20}$	$\frac{12}{19}$	$\frac{58}{72}$	$\frac{11}{15}$	$\frac{20}{30}$	$\frac{17}{25}$	$\frac{4}{5}$	$\frac{13}{19}$	-	$\frac{13}{21}$
1/83 - 9/83	$\frac{14}{15}$	$\frac{11}{11}$	$\frac{60}{78}$	$\frac{10}{10}$	$\frac{15}{17}$	$\frac{10}{14}$	$\frac{14}{16}$	$\frac{28}{35}$	-	$\frac{2}{2}$
TOTAL	$\frac{62}{85}$	$\frac{42}{61}$	$\frac{242}{535}$	$\frac{69}{135}$	$\frac{102}{209}$	$\frac{81}{122}$	$\frac{25}{33}$	$\frac{112}{183}$	-	$\frac{15}{23}$

34

Key: 1. Air Conditioning

2. Automatic Transmission

3. Brakes

4. Electrical Systems

5. Engines

6. Front Suspension/Wheel Alignment

7. Standard Transmission/Rear Axle

8. Tune-Up

9. Diesel Engine

10. Motorcycle/Motorscooter

#P = Number who passed exam

TOT = Total exams taken

APPENDIX C

Organization of Automotive Mechanics Technology Curricula by Proficiency Level

The organization of AMT curricula by proficiency level has been advocated by a number of vocational educators and automotive service industry professionals. Under this system, beginning students would first take a "block" of courses designed to equip them with preventive maintenance skills. Those who successfully completed these courses would be eligible to take classes at the second level of proficiency, light repair and component replacement, and students who successfully completed this block would be promoted to the third proficiency level, major component overhaul. The presentation of AMT courses at various proficiency levels has a number of advantages:

- (1) Because the number of students at each successive proficiency level would be expected to decline as avocational or undecided students leave the program, community college instructors could devote more time and resources to those most likely to pursue a career in the automotive service industry.
- (2) Employers would have a better ability to match AMT graduates with appropriate jobs. Thus, an employer trying to fill a position involving major component overhaul would be able to readily identify graduates who possess skills at this level.
- (3) The proficiency level format would enable AMT programs to cater to the diverse needs and interests of students in an efficient and cost-effective manner. For instance, AMT students who are undecided about their career aims or who are enrolled for avocational purposes could complete the preventive maintenance level and, if they wished, leave the program at that point with a useful body of knowledge and skills.

Among other examples of the organization of AMT curricula by proficiency level is the Ford Automobile Mechanic Curriculum Outline which consists of three blocks of instruction.

1. Basic Automotive Courses

A basic course covering safety, the use of service publications, and the technical knowledge and skills in all areas of the vehicle needed to reach a minimum skill level. The graduate will have terminal skills for employment as an Automotive Service Station Attendant (technically equivalent to DOT 915.467-010) or a background to advance to a higher level by attending the intermediate and advanced level courses.

Basic automotive courses are:

<u>Subject</u>	<u>Hours</u>
Shop Safety	8
Hand Tools	9
Power Tools	8
Fasteners	12
Service Publications	8
Engine, Cooling, Heating and Air Conditioning Systems	15
Ignition, Fuel and Emission Systems	12
Exhaust System	6
Brakes	12
Wheels and Tires	12
Steering and Suspension	12
Manual Transmission and Clutch	12
Automatic Transmission	9
Drive Shaft and Rear Axle	9
Battery, Starting and Charging Systems	15
Body Electrical	15
Headlamp Alignment	<u>6</u>
Total Hours	180

2. Intermediate Automotive Specialty Courses

A series of seven courses covering specialized areas of the vehicle. These courses are designed to provide skills and knowledge at an intermediate skill level. The graduate of all of the specialty courses will have terminal skills for employment as a mechanic at a mass merchandiser or as an entry-level mechanic at a new or used car dealer or independent repair shop.

This segment of the course has been specialized to provide flexibility in scheduling enrollees and to enable a student to progress to an intermediate skill level in the specific specialty of his choice without the necessity of attending courses in all technical areas of the vehicle.

Intermediate Specialty Courses are:

<u>Subject</u>	<u>Hours</u>
Brakes	30
Steering and Suspension	40
Basic Electricity	24
Body Electrical	56
Tune-Up	70
Engine Repair	70
Transmission Rear Axle	<u>70</u>
Total Hours	360

3. Advanced Automotive Specialty Courses

A series of eight courses covering specialized areas of the vehicle. These courses are designed to provide skills and knowledge at an advanced skill level. The graduate of all of the advanced specialty courses will have terminal skills for employment as an Automotive Mechanic (technically equivalent to DOT 620.261-010). The graduate should be able to successfully pass the National Institute for Automotive Service Excellence tests and be certified once he meets the Institute's job experience requirement.

Employment opportunities are as a specialized mechanic or as a general automotive mechanic with a new or used car dealer or independent repair shop.

Advanced specialty courses are:

<u>Subject</u>	<u>Hours</u>
Engine Repair	70
Automatic Transmission	70
Transmission and Rear Axle	70
Steering and Suspension	70
Brakes	40
Automotive Electrical	70
Heating and Air Conditioning	80
Tune-Up	<u>70</u>
Total Hours	540

FOOTNOTES

Part I. Introduction

1. "What the Experts Predict for the Decade Ahead," Motor Trend, January 1980, p. 26.
2. "Modern Cars Make Backyard Mechanics Obsolete," Honolulu Star-Bulletin, June 7, 1984.

Part II: The Impact of Technology on Automotive Design and Engineering

1. This subsection is based on the following articles: "High-Tech Cars for the Mid-'80's," Popular Science, January 1980, pp. 86-9; "Buck Rogers in the Twentieth Century," Motor Trend, January 1980, pp. 32-5; "1990: Small, Trim, Efficient and Nimble - The Car of the Future," Motor Trend, January 1980, pp. 28-31; "Your Car May Have a Mind of Its Own," Mechanics Illustrated, September 1980, pp. 56-7, 85-6; "Electronics in Your Next Car," Radio-Electronics, December 1980, pp. 45-8; "Dashboard Navigator Does Everything But Drive," Popular Mechanics, December 1980, pp. 112-3; "Electronics in Your Next Car," Radio-Electronics, March 1981, pp. 49-51, 88; "The Electronics Revolution," Road & Track, November 1982, pp. 52-6 and December 1982, pp. 154-7.
2. This subsection is based on a presentation made at the August 2-4, 1984 Hawaii High Technology Conference for Industrial Educators. The conference, sponsored by the Office of the State Director for Vocational Education (OSDVE) in cooperation with the Department of Education, University of Hawaii, Brigham Young University and CMFE, considered the impact of technology in five occupational areas: automotive mechanics, electricity/electronics, drafting, construction, and metals/manufacturing.

Part III: Labor Supply and Demand

1. Authorized Courses and Code Numbers: 1984-1985, Office of Instructional Services, Department of Education, August 1983, pp. 622-23.
2. Hawaii Five-Year and Multi-Year Plan for the Administration of Vocational Education, Office of the State Director for Vocational Education, University of Hawaii, June 1982, p. A-11.

3. Hawaii Employment Service (ES) statistics also suggest that there is a statewide labor surplus of automotive mechanics. ES figures on automotive mechanics applicants and job listings during the six-month period October, 1983 - March, 1984 are as follows:

	<u>Automotive Mechanics Applicants</u>	<u>Job Listings</u>
Oahu	186	44
Mauai	44	7
Hawaii	37	11
Kauai	<u>11</u>	<u>0</u>
TOTAL	278	62

4. Employment Outlook for Industries and Occupations: 1980-1990, Department of Labor and Industrial Relations, State of Hawaii, p. 76; "Occupational Employment Growth Through 1990," Monthly Labor Review, August 1981, p. 51.
5. Demand Occupations in Hawaii, Department of Labor and Industrial Relations, State of Hawaii, June 1984, p. 2.

Part IV: Interviews

1. Manpower Survey Project: A Survey of Industry Opinion, Honolulu Community College, July 1973, p. 43.
2. Manpower Survey Project, p. 45.
3. Content Identification and Validation: An Industrial Survey with Implications for Curriculum Development for Six Occupational Programs, Office of Instructional Services, Department of Education, February 1974, esp. pp. 11-16.